BATTERY WOX93E (EAGLE-PICHER CAP 6243)

EAGLE-PICHER INDUSTRIES, INCORPORATED

PREPARED FOR

NAVAL SURFACE WEAPONS CENTER

MAY 1975

EAGLE-PICHER INDUSTRIES, INC.

FINAL REPORT

BATTERY WOX93E

(EAGLE-PICHER CAP-6243)

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Battery WOX93E

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The WOX93E battery is a high spin thermal battery capable of providing 1 amp at 15 volts while undergoing an axial spin of 250 to 410 RPS. This report documents the development, testing and evaluation of the battery from July 1973 until May 1975.

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INTRODUCTION AND SUMMARY

The proposed program involved development of a high spin thermal battery capable of providing approximately 1 amp of power while undergoing an axial spin of 250 to 410 RPS.

The main problems anticipated in high spin development were:

1) Ignition failure as a result of centrifugal force throwing the fuse trains away from the cell stack, thus preventing intimate enough contact between the fuse and pellet to activate the cells; and

2) Cell shortage occurring during centrifuging, when electrolyte oozes out of the cells and through the stack wrap.

The initial technical solution to these problems centered around development of a unique type of pellet design which placed most of the pellet mass slightly off center.

Theoretically, by using this "D" cell configuration, the centrifugal force generated by battery spin would actually press the battery stack against the fuse trains, creating the desired intimate contact between fuse train and heat pellet. Simultaneously, this increased intimate contact between fuse trains and pellet would reduce considerably the free area through which the pellets would lose electrolyte due to centrifugal force.

In accordance with the "D" cell design concept, the first two months of the program, July 1 through August 31, 1973, were devoted to the following activities:

1) All tooling was procured, the last tool being received on August 30.

2) All piece parts were delivered by August 30, except headers from Astro Seal and heat paper from Unidynamics.

3) Preliminary drawings were given to drafting for completion.

4) Manufacturing procedures and processes were outlined.

5) The "on paper" design for Lot 1A was completed.

The following six months, September 1973 through February 1974, were devoted to development, testing, and evaluation. Areas of concentration included proper heat balance to achieve maximum life; utilization of heat pellets with and without grid; variations in the percentage ratio of depolarizer, eutectic and binder in the DEB; variations in closing pressure. Several conclusions were drawn. First, the exclusion of grid in the heat pellets resulted in hotter heat per unit weight, and produced batteries which were balanced too hot. Future heat pellets would be manufactured with grid. Second, the percentage ratio binder studies revealed that best results were obtained using a DEB pellet consisting of 35% depolarizer, 50% eutectic and 15% binder. High spin battery studies conducted at Sandia Corporation also pointed to 15% binder as an optimum ratio. Third, calculations of the closing force used on the "D" cell area showed that the initial 750 lb. total force was roughly equivalent to 1,043 lb. on the Sandia system. A more satisfactory range was effected by lowering the closing pressure to 600 lb.

In conjunction with battery development and evaluation, feasibility studies were conducted for a high spin battery utilizing a 1¼" annular cell instead of the present "D" cell design. The cost of additional tooling was computed and filed for future reference.

In mid-February 1974, Eagle-Picher and NOL received information from Sandia confirming their use of type 86/14 heat powder in their high spin battery rather than the 88/12 mix put forward in the November 28, 1973, meeting at Eagle-Picher. This had a tremendous impact because the 86/14 is much more ignition sensitive than the 88/12 iron powder/potassium perchlorate mixes.

For this reason, test batteries were fabricated utilizing type 86/14 heat powder. When fired, 100% ignition was attained.

All work was stopped until a joint conference could be held between NOL and Eagle-Picher on February 28, 1974. The following decisions evolved from the conference:

1) Future work should be devoted to using the 86/14 heat powder to closely parallel Sandia's research findings.
2) Purchase orders should be placed immediately to procure tooling for a 1¼" cell.

The period from March 1 through June 30, 1974, was primarily devoted to minor design changes for purposes of meeting new drawing specifications per NOL Drawing 73D-1747, Rev. B, dated July 1, 1974, and to further minimize problems due to electrolyte leakage. Additional DEB binder percentage ratio experiments confirmed 15% binder as an optimum. Noise, a continuing problem throughout battery development, was now considered to be the final obstacle in reaching the specified design goal. Voltage trace observations indicated that noise elimination would extend battery life beyond the design goals. Therefore, final efforts of the program would be devoted to solving the noise problem.

A summation review of noise problem trends revealed the following:

1) Noise levels were of two (2) types, one severe enough to drop battery voltage below minimum specification, and one so light that it did not appear to affect battery performance.
2) The severe noise level occurred at higher temperatures, while the slight noise level occurred early in battery performance at all temperatures.

3) The noise level was related to spin environment. Post mortems show evidence of electrolyte leakage in specified battery areas related to noise.

4) The severe noise level was affected by the percent of binder in the DEB cell. Results of 15% binder versus 20% binder showed superior performance at the 15% level.

5) Post mortems revealed that electrolyte leakage was located predominately at the center of the stack or near the center lead, indicating that the center portion of the battery stack was hotter than the ends, thus causing the electrolyte to be more fluid.

As a preliminary step in solving the noise problem, a small computer study was run on the battery performance of previous builds. This study correlated voltage at 70 seconds and life to 12 volts with DEB weight, heat weight, and battery test temperatures. Results showed that best battery performance was achieved when:

1) The heaviest DEB was used.

2) The lightest heat pellet was used.

3) The battery was fied at the high temperature extreme.

When consideration was given t both the central location of electrolyte leakage and the fact that noise levels were not necessarily related to test temperature, computer analysis results pointed to a reduction in stack heat with a simultaneous increase in secondary, or end, heat as a preliminary solution.

The next four months, July 1 through October 30, 1974, was devoted to noise problem experiments which included rebalancing of heat and 12½% versus 15% binder tests. Also, annular cells were fabricated and tested for the first

time in the program. With the introduction of the annular cell configuration, noise was virtually eliminated and battery life was extended.

At this point, the overall conclusion was that a different type of insulation was needed to better prevent the large mass of the case and simulated electronics enclosure from drawing heat away from the cell stack too rapidly. With this objective in mind, investigations were initiated on tube type insulators using MIN-K and fiberfrax. A drawing of the tube type insulator is shown.

The final two minths of 1974 involved comparison testing of the new tube type insulation versus the previous standard wrap method, and comparison of insulating materials.

Several malfunctions in the spinner were discovered and repaired at this time. Repairs included:

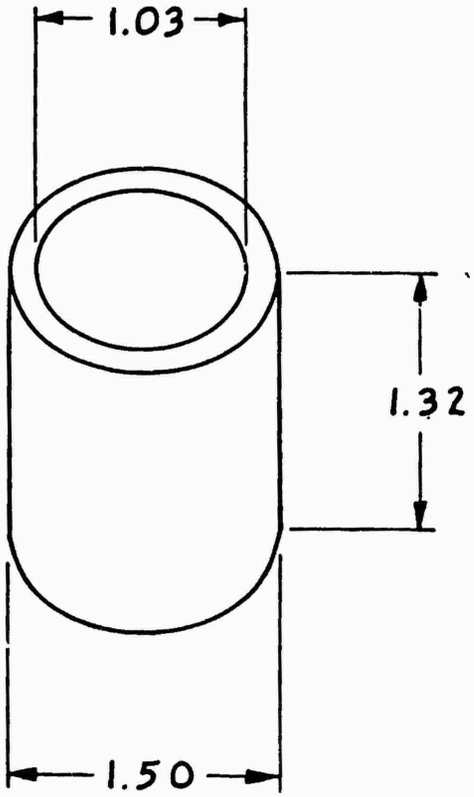
1) New terminals in the battery fixture and spinner.

2) Re-soldering of the joint between the female battery terminal and the load resistor.

3) New connection wires inside the spinner.

Testing after repair of the spinner revealed excellent battery performance, therefore a build was made in January 1975 utilizing the optimum design configuration and chemical components, as revealed by all prior studies. Testing showed that noise was again present in some batteries. Investigation again revealed serious problems in the test equipment. Testing on Eagle-Picher's spinner was halted. It was later found that the entire brake assembly was worn out and was shorting together. This was the most probable cause of the noise problems and reduced life in the most recent build.

Therefore, a final build was fabricated and was sent directly to NOL with no spin tests being performed at Eagle-Picher, since accurate data was not possible at this time.



RIGID INSULATOR

MIN-K. OR FIBERFRAX

The entire program was divided into nine lots. Pertinent build data and discharge summaries for each lot follow and are supported by engineering drawings and/or charts when applicable.

LOT 01

First batteries fabricated on September 24, 1973

1) DEB = (6199 Type One Step Material) = .70 gm/pellet or 12.60 gm/stack (.026" thk.)

2) Heat = (NX1000 Heat Powder) = 1.10 gm/pellet or 20.90 gm/stack (.018" thk.)

3) Batteries wrapped and welded off with a stack pressure of 750# total force.

4) Miscellaneous build data:

   a) Header Assembly = 1 - .062" with 2 ea. 1/8" holes (asbestos)
      1 - .062" with 2 ea. 1/4" slots for leads to fold into (asbestos)

   b) Bottom of Can = 1 - .062" asbestos with 1/2" center hole
      1 - .032" asbestos with 1/2" center hole
      1 Heat pad = 1.375 dia. = 1.13 gm = 420 cal/gm paper

5) Stack fabrication:

   a) 2 stacks of 8 cells each in parallel

   b) 1 - .010" asbestos end disc used on each end of cell stack

   c) Fuse train - 1 ea. = 1/2" wide x 1-5/8" long (420 cal/gm)

   d) 2 stack wraps of .040" fiberfrax = 1-1/8" wide x 8-3/4" long (1 piece wrapped around twice)

   e) 2 wraps of .007" glass cloth tape = 1/2" wide x 48" long (1 piece wrapped around twice)

   f) Used CAP-6166 headers cut down to fit because our headers aren't delivered het

   g) Mica case liner - 1-3/16" wide x 5" long

LOT 01
TEST RESULTS

No Spin - Bench Tests - Tested 10/19/73

S/N	Test Temp	R.T. to 14 V.	Peak Volts	Life to 14 V
J3-13-21	+ 20°F	.220	20.8	123
J3-13- 3	+ 20°F	.265	20.9	163
J3-13-20	- 20°F	.240	20.9	105
J3-13-12	- 20°F	.250	20.8	129
J3-13- 6	+135°F	.180	20.7	70
J3-13-24	+135°F	.225	20.8	105

LOT 01
TEST RESULTS

S/N	Test Temp	Axial Spin	Rise to 14V	Peak Volts	Life to 14V	Comments
J3-13- 1	- 20°F	300 RPS	.200	21.01	22	.4 V blips beginning at 2.9 Sec. 1 V noise beginning at 6.6 Sec. 1.8 V noise at 12 Sec.
J3-13- 5	- 20°F	300 RPS	.280	21.06	15	1 V blips beginning at 3.0 Sec. 2.3 V noise 5 Sec. to Life
J3-13- 4	+135°F	300 RPS	.200	20.68	50	.5 V noise 2.5 Sec. on
J3-13- 8	+135°F	300 RPS	.170	20.96	48	.5 V noise 7-26 Sec. 1.2 V noise 26-31 Sec.
J3-13-1[illegible]	- 20°F	200 RPS	.190	20.78	61	1.2 V noise 5-42 Sec. 3 V noise 42 Sec.
J3-13-11	+135°F	200 RPS	.200	21.01	57	.5 V noise 3-46 Sec. 1 V noise 46-48 Sec.

LOT 01
TEST RESULTS

S/N	#2	#7	#10	#22
Temp.	+135°F	+135°F	-25°F	-25°F
Spin	300 RPS	200 RPS	300 RPS	200 RPS
R.T. to 14 V	.190	.300	.230	.250
Peak Volts	20.6	17.1	20.9	20.3
Life to 14 V	52	51	53	56
Volts @ 10 Sec.	19.8	-	19.1	19.7
Volts @ 20 Sec.	18.9	-	18.8	19.1
Volts @ 30 Sec.	17.8	-	18.8	18.8
Volts @ 40 Sec.	15.3	-	18.1	17.8
Volts @ 50 Sec.	14.3	-	15.1	15.7
Comments:	.6 V Spikes 5-Life (Very Few)	3 V Noise Start to Life	.5 V Noise 2.5 Sec. - Life	.5 V Spikes 3.5 Sec. - Life (Not many)

LOT 02
BUILD INFORMATION

GROUP I

L3-27-1*, 2*, 3, 4:	DEB - 10% - .65 gm. Heat - 1.10 gm. - no grid Standard wrap	(1 extra .031" asbestos wrap (put around battery to make (stacks tight in can.
L3-27-5*, 6*, 7, 8:	DEB - 10% - .65 gm. Heat - 1.10 gm. - no grid New wrap	

GROUP II

L3-27-9*, 10*, 11, 12:	DEB - 15% - .65 gm. Heat - 1.00 gm. - no grid Standard wrap
L3-27-13*, 14*, 15, 16:	DEB - 15% - .65 gm. Heat - 1 gm. - no grid New wrap

GROUP III

L3-27-17*, 18*, 19, 20:	DEB - 20% - .65 gm. Heat - .95 gm. - no grid Standard wrap
L3-27-21*, 22*, 23, 24:	DEB - 20% - .65 gm. Heat - .95 gm. - no grid New wrap

* Shipped as first half Lot 02, rest shipped after test and post mortem.

LOT 02
TEST RESULTS

S/N	Test Temp	RPS Spin	R.T. to 14 V	Peak Volts	Life to 14 V	V. @ 10Sec.	V. @ 20Sec.	V. @ 30Sec.
L3-27- 3	+135°F	300	.375	20.5	16.5	18.4	--	--
			(1 volt noise 13.5 sec. to life)					
L3-27- 7	+135°F	300	.375	20.8	23.8	19.3	16.0	--
			(1 volt noise 23 sec. to life)					
L3-27-11*	+135°F	300	--	20.6	43.0	--	--	--
L3-27-15*	+135°F	300	--	20.4	17.0	--	--	--
L3-27-19	+135°F	300	.400	20.0	17.0	17.8	--	--
			(1 volt noise 19 sec. on) (8.5 volt drop @ 23 sec.)					
L3-27-23	+135°F	300	.500	21.6	4.0	13.2	--	--
			(vented badly around primer holder)					
			(7 volt drop @ 4.0 sec.--dropped to 13.8 volt)					
L3-27- 8	+ 25°F	300	.450	20.6	28.0	19.6	17.0	13.2
			(1 volt noise 1 sec. on)					
L3-27- 4	+ 25°F	300	.300	20.8	29.0	19.6	16.3	13.4
			(noise after life ≈ 31 sec.)					
L3-27-12	+ 25°F	300	.280	19.2	33.8	16.0	15.3	14.5
			(4 volt drops and rises--3.5 sec. to 8 sec.-- then smoothed out) (Noise after life)					
L3-27-16	+ 25°F	300	.450	20.6	66.0	20.4	20.0	19.6
			(1 volt noise 63 sec. on) (19.0 v @ 40 sec.)					
			(18.0 v @ 50 sec.) (16.7 v @ 60 sec.)					
L3-27-20	+ 25°F	300	.500	20.4	30.6	19.4	17.6	14.3
			(no noise at all)					
L3-27-24	+ 25°F	300	.275	20.3	31.0	19.3	17.8	14.1
			(no noise at all) (13.2 v @ 40 sec.)					

* Test equipment failure--no voltage trace--readings off DVM and clock.

LOT 03

Sixteen (16) batteries were fabricated on 11 March 1974 to four (4) different configurations.

1) All batteries in Lot 03 had the following:
   a) Used 600 lb. stacking and weld pressure.
   b) Used two (2) 2174 (1/2" wide) fuse strips side by side.
   c) Changed heat powder from 88/12 to 86/14 powder.
2) The basic variations of the four (4) groups were the 15% and 20% binder in the DEB, and changes in heat value of the 86/14 powder.
3) The ignition problem has been solved--all batteries showed no evidence of partial ignition. The more sensitive heat powder, 86/14, will be used from this point on.
4) Best performance was with the .90 g DEB, but the performance showed the battery to be heat balanced on the cool side. Additional heat balances will be used in the next lot.
5) Complete Lot 03 data is enclosed.

LOT 03
11 MARCH 1974

Changes:

1) On all groups use 600# stacking and weld pressure.

2) On all groups use two inner wraps of fiberfrax with a .007" glass cloth tape outer wrap.

3) Still use the two 2174 (1/2" wide) fuse strips side by side as in the B4-20 series.

4) Leave the leads in the same position as the B4-20 battery.

Group I: (C4-14-1 to 4)

DEB (15% binder material)
wt. -- .80 gm/pellet
thk. -- .031 ± .001" thk.
(density range 1.73 to 1.80 gm/cc)

Heat Pellets (86/14 Powder)
wt. -- 1.00 gm/pellet
thk. -- .020 ± .001" thk.
(density range -- 3.30 to 3.65 gm/cc)

Group II: (C4-14-5 to 8)

DEB (15% Binder Material)
wt. -- .80 gm/pellet
thk. -- .031 ± .001" thk.
(density range 1.73 to 1.80 gm/cc)

Heat Pellets (86/14 Powder)
wt. -- .90 gm/pellet
thk. -- .018 ± .001" thk.
(density range -- 3.30 to 3.65 gm/cc)

Group III: (C4-14-9 to 12)

DEB (20% Binder Material)
wt. -- .80 gm/pellet
thk. -- .031 ± .001"
(density range -- 3.30 to 3.65 gm/cc)

Heat Pellets (86/14 Powder)
wt. -- 1.00 gm/pellet
thk. -- .020 ± .001"
(density range -- 3.30 to 3.65 gm/cc)

Group IV: (C4-14-13 to 16)

DEB (20% Binder Material)
wt. -- .80 gm/pellet
thk. -- .031 ± .001"
(density range -- 3.30 to 3.65 gm/cc)

Heat Pellets (86/14 Powder)
wt. -- .90 gm/pellet
thk. -- .018 ± .001"
(density range -- 3.30 to 3.65 gm/cc)

One half of each group will be tested at Eagle-Picher and one half will be shipped to NOL.

LOT 03
(NOL TEST REPORT)

S/N	Load Ω	T °F	RPS	Act 14	Peak Volts	Life 14	Noise
15% Binder							
1	23	- 25	300	.35	20.6	95	1 v @ 88 Sec.
2	23	+135	300	.48	20.0	44	3 v @ 43 Sec.
3	26	+ 70	300	.23	20.52	60	None for 47 Sec.
4	26	- 25	300	.32	20.49	93	.2 v
5	26	+ 35	300	.28	20.71	61	< 1
6	26	+135	300	.28	20.67	104	.1 v
7	23	+135	300	.30	20.7	98	Yes
8	23	- 25	300	.50	20.7	50	Yes
20% Binder							
10	23	- 25	300	.25	17.5	10	Saddle
12	23	+135	300	.30	18.7	16	
14	23	- 25	300	.50	18.2	30	1 v Saddle
16	23	+135	300	.25	19.4	39	
B4-13-5	23	+ 70	300	-	1.		
B4-13-6	23	+ 70	300	.45	20.32	26	

17<

LOT 03

	S/N	Test Date	Test Temp	RPS Spin	RT to 14V	Peak Volts	Volts @ 10Sec.	Ve 20Sec.	Ve 30Sec.	Ve 40Sec.	Ve 50Sec.	Ve 60Sec.	Life to 14 Volts	Comments
Group I 10% 1.6C Heat	C4-14-1	3/21/74	-25	300	.350	20.6	20.5	20.3	19.9	19.8	19.1	18.7	95 Sec.	(1 Volt Noise beginning @
	-2	3/21/74	+135	300	.480	20.0	19.9	19.6	18.7	17.8			44 Sec.	(3 Volt Noise 4.3 Sec. e
	-3													
	-4													
Group II 10% .9C Heat	-5													
	-6													
	-7	3/20/74	+135	300	.300	20.7	20.7	20.2	20.0	19.8	19.2	18.8	98 Sec.	Noise caused end of l
	-8	3/20/74	-25	300	.500	20.7	20.4	20.2	20.0	18.9	14.0		50 Sec.	clean up to that point
Group III 20% 1.0C Heat	-9													
	-10	3/21/74	-25	300	2.50	17.5							10 Sec.	(Saddle in Rise Time.
	-11													
	-12	3/21/74	+135	300	.300	18.7	17.0	13.0					16 Sec.	
Group IV 20% .9C Heat	-13													
	-14	3/20/74	-25	300	.500	18.2	18.0	17.2	14.0				30 Sec.	(1V Saddle after Rise)
	-15													
	-16	3/20/74	+135	300	.250	19.4	19.4	19.0	16.8	13.8			39 Sec.	

(Also shipped S/N B4-13-5 & 6 and B4-20-5 & 6 to make the 20 lot size)

LOT 04

Twenty (20) batteries were fabricated on 12 April 1974 to five (5) different configurations.

1) All batteries in Lot 04 had the following changes:
   a) The number of cells in each parallel stack was reduced from 8 to 7 cells each.
   b) The battery case was also lengthened per NOL Drawing 73D-1747, Rev. B_4. (From 1.350 max. to 1.475 $\pm$ .010)
   c) The location of the battery leads were changed as shown in Figure 1. This was to keep the leads away from the areas of electrolyte leakage as indicated by the post mortems.
   d) The closing pressure was reduced to 600 lb. from the previous 750 lb.
   e) Two fuse trains as in batteries C4-14-5 to C4-14-8 were installed.
2) The basic variation of the five groups were in the DEB weight and heat pellet weight. The summary sheet, page 20, gives the weight variation of each group.
3) The 15% binder in the DEB again, as in Lot 03, showed far better results.
4) The best performance of the 15% binder in the DEB was Group 2 of Lot 04 at the +135°F temperature. This battery ran 154 seconds to 12 volts while the +20°F battery ran 59 seconds. Better performance was also achieved with Groups 1 and 3 which had the same DEB weight as Lot 03, but with a different heat balance.

5) Noise still seems to be a problem, particularly at the end of life. This is causing the high temperature batteries to run excellent voltages until the noise abruptly kills the voltage, causing a shortened battery performance.

   a) The exact cause is not known. However, post mortems of the batteries indicate that electrolyte leakage occuring at the edges of the cell causes shorting and overheating.

   b) The possibility also exists that the CaLi alloy formation may also be a part of the noise problem.

6) Post mortem of the above mentioned batteries is included (S/N 12 and 6).

7) The stack insulation of the batteries in Lot 04 were changed as noted in the summary sheet. Glass cloth tape was next to the stack, alternating with .020" fiberfrax.

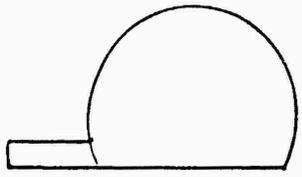
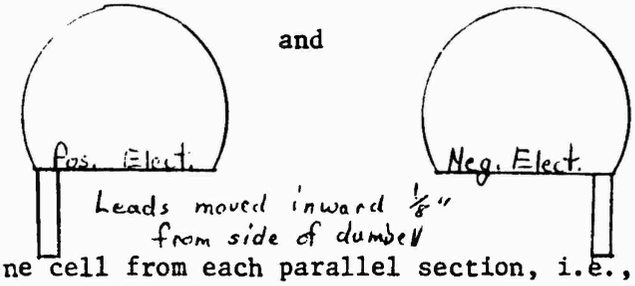
LOT 04
12 APRIL 1975

Instructions for the next 6243 build:

1) 600 pounds stack and closing pressure.

2) Two fuse trains as in batteries C4-14-5 to 8.

3) Move leads to flat side of electrode:

From  to 

and

4) Build the stack by dropping out one cell from each parallel section, i.e., use two parallel 7's instead of two parallel 8 sections.

Group I: (4 batteries)

1) DEB (15% binder)

   a) Weight = .80 gm/pellet
   b) Thickness = .031 ± .001"
   c) Density range = 1.73 to 1.80 gm/cc

2) Heat (86/14 type lot 1211)

   a) Weight = .90 gm/pellet)
   b) Thickness = .018 ± .001") with grid
   c) Density range = 3.30 to 3.65 gm/cc)

3) Wrap as follows:

   a) Three wraps of .040" fiberfrax
   b) Bring up leads with mica underlay
   c) One outer wrap of .005 glass cloth tape
   d) Mica case liner

Group II: (4 batteries)

1) DEB (15% binder)

   a) Weight = .90 gm/pellet
   b) Thickness = .034 ± .001"
   c) Density range = 1.77 to 1.85 gm/cc

2) Heat (86/14 type lot 1211)

a) Weight = 1.00 gm/pellet)
b) Thickness = .020 ± .001") with grid
c) Density range = 3.30 to 3.65 gm/cc)

3) Wrap as follows:

a) One inner wrap of .005" glass cloth tape
b) Three wraps of .040" fiberfrax
c) Bring up leads with mica underlay
d) One wrap of .007" glass cloth tape
e) Mica case liner

Group III: (4 batteries)

1) DEB (15% binder)

a) Weight = .80 gm/pellet
b) Thickness = .031 ± .001" thick
c) Density range = 1.73 to 1.80 gm/cc

2) Heat (86/14 Lot 1211)

a) Weight = .95 gm/pellet)
b) Thickness = .019 ± .001" thick) with grid
c) Density range = 3.28 to 3.65 gm/cc)

3) Wrap as follows:

a) One inner wrap of .005 glass cloth tape
b) Three wraps of .040" fiberfrax
c) Bring up leads with mica underlay
d) One outer wrap of glass cloth tape
e) Mica case liner

Group IV: (4 batteries)

1) DEB (20% binder)

a) Weight = .80 gm/pellet
b) Thickness = .031 ± .001 thick

2) Heat (86/14 type lot 1211)

a) Weight = 1.10 gm/pellet)
b) Thickness = .022 ± .001") with grid
c) Density range = 3.45 to 3.62 gm/cc)

3) Wrap as follows:

a) One inner wrap of .005 glass cloth tape

b) Three wraps of .040" fiberfrax
c) Bring up leads with mica underlay
d) One wrap of glass cloth tape
e) Mica case wrap

Group V: (4 batteries)

1) DEB (20% binder)

a) Weight = .80 gm/pellet
b) Thickness = .031 ± .001 thick

2) Heat (86/14 type lot 1211)

a) Weight = 1.00 gm/pellet)
b) Thickness = .020 ± .001") No grid

3) Wrap as follows:

a) One inner wrap of .005 glass cloth tape
b) Three wraps of .040" fiberfrax
c) Bring up leads with mica underlay
d) One wrap of glass cloth tape
e) Mica case wrap

LOT 04
SANDIA FURNISHED BATTERIES
FIRED IN OUR SPIN TESTER

Built @ Sandia 2/4/74
Tested 4/10/74

S/N 104 75°F 300 RPS

(Load wired up backwards by Electronics)

S/N 103 75°F 300 RPS

R.T. to 20 V	Peak Volts	Volts @ 10 Sec.	Volts @ 20 Sec.	Volts @ 30 Sec.
.325	30.9	30.5	30.8	30.2

Volts @ 40 Sec.	Volts @ 50 Sec.	Volts @ 60 Sec.	Volts @ 70 Sec.	Volts @ 80 Sec.	Volts @ 90 Sec.
30.0	29.3	28.9	28.2	27.8	27.2

Volts @ 100 Sec.	Volts @ 110 Sec.	Volts @ 120 Sec.	Volts @ 130 Sec.	Volts @ 140 Sec.
26.2	25.0	23.2	21.5	20.0

Time to 20 Volts = 141 Sec.

Time 51 14 Volts = 182 Sec.

(Fired under 70 ohm load)

Current Density = .23 amps/sq. in.

R.T. to 24 Volts = .375 Sec.

Life to 24 Volts = 118 Sec.

LOT 04

		Act. To 12 V	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	Life To 12V
GROUP I																		
S/N																		
E4-1- 1	+ 75°F		18.2	17.9	17.6	17.3	16.5	14.2	11.0	8.3	7.3							67
E4-1- 2	+135°F		Wired Wrong in Spin Equipment, Over 100 Sec. - No Noise															(Time by Clock)
E4-1- 3	+165°F		18.1	17.9	17.7	17.5	17.1	16.7	16.1	15.1	13.8	12.9	12.2	11.7	11.3			114
E4-1- 4	+ 20°F		18.3	18.2	18.1	17.8	17.2	16.2	14.2	11.9								79
GROUP II																		
E4-1- 5	+ 75°F	.52	18.1	17.9	17.6	17.3	16.7	14.7	11.5	9.1	8.0							69
E4-1- 6	+135°F	.25	18.3	18.2	18.1	18.0	17.8	17.4	17.0	16.8	16.4	15.8	14.8	13.8	13.1	12.8	12.1	154
E4-1- 7	+ 20°F	.40	18.3	18.1	17.9	17.4	15.5	11.9										59
E4-1- 8	+165°F	.36	18.2	18.0	17.7	17.4	17.0	16.5	15.5	14.4	13.4	12.8	12.3	11.9	11.4	11.0	10.5	117
GROUP III																		
E4-1- 9		.28	18.2	18.0	17.8	17.5	17.1	16.7	15.9	14.8	13.9	13.2	12.5	11.9	11.6			119
E4-1-10	+ 75°F	400RPS	18.1	17.9	17.6	17.2	16.8	16.2	15.0	13.6	12.7	12.0	11.5	11.1	10.6			100
E4-1-11	+ 20°F	.25	18.3	18.2	18.1	17.8	17.5	16.8	14.8	11.5								78
E4-1-12	+135°F	.10	18.3	18.2	18.1	17.6	17.0	16.5	16.0	13.8	7.8	(Noise at 77 Sec.)						85
GROUP IV - 20% BINDER																		
E4-1-13			17.6															21
E4-1-14	+ 20°F	.20	17.4	16.8	6.2	(Noise at 24 Sec.)												26.5
E4-1-15	+135°F	.15	16.8	9.5		(Noise at 17 Sec.)												19
E4-1-16																		
GROUP V - 20% BINDER																		
E4-1-17	+ 75°F																	
E4-1-18	+135°F	.15	17.2	16.1	7.3	(Noise at 22 Sec.)												25
E4-1-19	+ 20°F	.20	17.3	17.7	16.4	14.0	7.0	(Noise at 40 Sec.)										42
E4-1-20																		

LOT 05

Twenty (20) batteries were fabricated on 13 May 1974 to five (5) different configurations.

1) All batteries in Lot 05 had the following:
   a) Used two (2) 2174 (1/2" wide) fuse strips side by side
   b) All used the 86/14 iron heat powder
   c) All used 15% binder in the DEB
   d) All were closed and pressed at 600 lb. stack pressure
2) The idea of Lot 05 was to look at increasing the cell weights with a couple of heat balances. Increasing cell weight was giving us longer life. The only variation of this was in Group 5 of Lot 05, where increasing the end heat was tried.
3) The results were the best of any lot previous. Group 4 did show performance of more than 100 seconds at +20°F to +135°F. The most obvious detriment was the noise. The noise or cell shorting at end of life at the high temperature causes the hot life to be shorter than the slope of the voltage trace would indicate it should be.
4) The next lot will try and solve the noise problem or at least help it considerably. If this can be done, the life of 100 seconds can be made reliably.

LOT 05

Group I (4 batteries)

1) DEB (15% Binder)
   a) Weight .90 gm/pellet
   b) Thickness .034 ± .001"
   c) Density Range 1.77 to 1.85 gm/cc

2) Heat (86/14 Type Lot 1211)
   a) Weight 1.05 gm/pellet
   b) Thickness .021 ± .001"
   c) Density Range 3.29 to 3.62
   d) With Grid

3) Wrap as follows
   a) One inner wrap of .005 glass cloth tape
   b) Three wraps of .040" fiberfrax
   c) Bring up leads with mica underlay
   d) One wrap .005 glass cloth tape
   e) Mica case liner

Group II (4 batteries)

1) DEB (15% Binder)
   a) Weight .90 gm/pellet
   b) Thickness .034 ± .001"
   c) Density Range 1.77 to 1.85 gm/cc

2) Heat (86/14) Type Lot 1211)
   a) Weight 1.10 gm/pellet
   b) Thickness .022 ± .001"
   c) Density 3.30 to 3.65 gm/cc
   d) With grid

3) Wrap as follows
   a) One inner wrap of .005 glass cloth tape
   b) Three wraps of .040" fiberfrax
   c) Bring up leads with mica underlay
   d) One wrap .005 glass cloth tape
   e) Mica case liner

Group III (4 batteries)

1) DEB (15% Binder)
   a) Weight 1.00 gm/pellet
   b) Thickness .038 ± .001"
   c) Density Range 1.77 to 1.87 gm/cc

2) Heat (86/14 Type Lot 1211)
   a) Weight 1.15 gm/pellet
   b) Thickness .023 ± .001"
   c) Density Range 3.30 to 3.65 gm/cc
   d) With grid

3) Wrap as follows
   a) One inner wrap of .005 glass cloth tape
   b) Three wraps of .040" fiberfrax
   c) Bring up leads with mica underlay
   d) One wrap .005 glass cloth tape
   e) Mica case liner

Group IV (4 batteries)

1) DEB (15% Binder)
   a) Weight 1.00 gm/pellet
   b) Thickness .038 ± .001"
   c) Density 1.77 to 1.87 gm/cc
   d) With grid

2) Heat (86/14 Type Lot 1211)
   a) Weight 1.25 gm/pellet
   b) Thickness .025 ± .001"
   c) Density 3.30 to 3.65 gm/cc
   d) With grid

3) Wrap as follows
   a) One inner wrap of .005 glass cloth tape
   b) Three wraps of .040" fiberfrax
   c) Bring up leads with mica underlay
   d) One wrap .005 glass cloth tape
   e) Mica case liner

Group V (4 batteries)

1) DEB (15% Binder)
   a) Weight .90 gm/pellet
   b) Thickness .034 ± .001"
   c) Density Range 1.77 to 1.85 gm/cc

2) Heat (86/14 Type Lot 1211)
   a) Weight 1.00 gm/pellet
   b) Thickness .020 ± .001"
   c) Dens. / Range 3.30 to 3.65 gm/cc

3) End Heat
   a) Add one additional heat pellet to end heat. Locate next to existing outside heat pellet, separated by .020 asbestos disc.

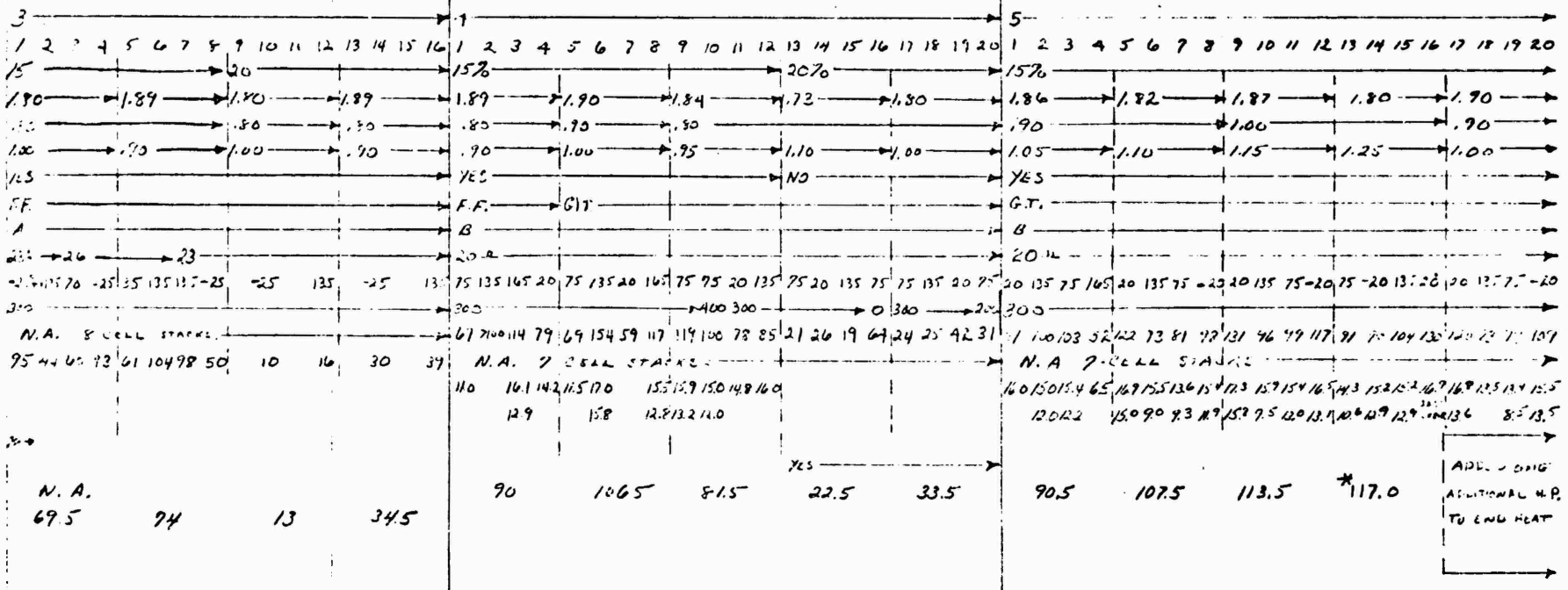
4) Wrap as follows
   a) One inner wrap of .005 glass cloth tape
   b) Three wraps of .040" fiberfrax
   c) Bring up leads with mica underlay
   d) One wrap .005 glass cloth tape
   e) Mica case liner

#6243 LOT #5 20 SEC 1.040 300RPS MAY 21, 1974

GROUP	SHT.	HEAT WT	LEAD WT	TEMP	ACT TO 6V	LIFE TO 12V	P.V.	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	
1	1	1.05g	.90g	+20°F	.25	81	18.3	18.1	18.0	17.8	17.7	17.4	17.0	16.0	12.9	8.3								
	2	"	"	+135°F	.20	100.	18.1	18.0	17.9	17.7	17.5	17.0	16.3	15.0	13.9	12.9	12.0	11.4	10.9					
	3	"	"	+75°F	.23	103.	18.0	17.9	17.8	17.6	17.3	16.8	16.3	15.4	14.0	13.1	12.2	11.4	10.9	10.4				2 KC NOISE
	4	"	"	+161°F	.40	52	17.86	17.7	17.5	16.9	15.9	13.3	9.0	6.5	6.4									200MV AT 43 SEC
2	5	1.10g	.90g	+20°	.25	122	18.1	18.0	18.0	17.9	17.7	17.5	17.2	16.9	16.3	15.8	15.0	13.9	12.3	10.9				
	6	"	"	+135°	.20	93	18.2	18.2	18.1	17.9	17.3	16.9	16.2	15.5	14.9	13.2	9.0							1 V. NOISE AT 89 SEC.
	7	"	"	+75°	.31	81	18.1	18.0	17.8	17.4	16.9	16.2	15.1	13.6	12.2	8.8	9.3	8.6						100MV " "
	8	"	"	−20	.32	98	17.99	17.9	17.7	17.5	17.3	16.9	16.4	15.4	13.9	12.7	11.9	11.2	10.8					100MV " 11.5, 15.5, 20, 26
3	9	1.15g	1.00g	+20°	.29	131	18.3	18.3	18.2	18.1	17.9	17.7	17.5	17.3	16.9	16.5	15.8	14.8	13.5	12.1	10.5			
	10	"	"	+135°	.27	96	18.3	18.2	18.1	17.9	17.5	17.0	16.5	15.9	15.2	14.2	9.5							NOISE AT 92 SEC
	11	"	"	+75°	.34	99	18.07	18.0	17.9	17.7	17.3	16.9	16.3	15.4	15.4	14.2	13.0	11.9	11.0	10.3				
	12	"	"	−20	.37	117	18.07	18.0	17.8	17.7	17.3	17.0	16.5	16.5	15.6	14.2	13.1	12.4	11.8	11.3	10.9	10.4		
4	13	1.25g	1.00g	+75°	.31	91	18.2	18.0	17.8	17.3	16.6	15.8	15.0	14.3	13.3	12.0	10.6							
	14	"	"	−20	.49	98	18.26	18.1	17.9	17.5	17.1	16.6	16.0	15.2	15.2	14.2	12.9	11.7	10.5					
	15	"	"	+135°F	.25	104	18.3	18.2	18.1	17.8	17.1	16.5	15.8	15.2	14.7	14.0	12.9	8.5						NOISE AT 103 SEC
	16	"	"	+20°F	.28	≈ 130	18.32	18.2	18.1	18.0	17.9	17.5	17.2	16.9	(RAN OUT OF PAPER)									
5	17	1.00g	.90g	+20°F	.18	120	18.22	18.3	18.1	18.0	17.8	17.8	17.3	16.9	15.9	14.7	13.6	12.8	12.0	11.0				
	18	WITH EXTRA HEAT		+135°F	.15	73	18.3	18.2	18.0	17.4	16.8	15.7	15.1	13.5	8.0									NOISE AT 69 SEC.
	19	PELLET IN EACH END		+75°F	.31	79	18.26	18.0	17.8	17.0	16.3	15.3	14.3	13.4	13.4	11.2	8.5	7.9						SLUGGISH NOISE.
	20	ASSY.		−20°F	.37	109	18.3	18.0	17.8	17.6	17.4	17.0	16.3	15.5	15.5	14.5	13.5	12.7	11.8	10.7	9.2			

TOTAL $\bar{X}$ = 95.855sec

SUMMARY WOX735
EAGLE-PICHER CAP-6243



Lee Lusk.
15 JUNG 74

LOT 06

Forty (40) batteries were fabricated on October 11 to three (3) different configurations. Twenty-five (25) batteries were "D" cell configurations at two (2) different percents of binder and fifteen (15) batteries were annular cell configurations. (The build sheet is attached.)

A new lot of heat powder, #1224 which is a 86/14 blend, was used in Lot 06. Therefore, Group I, nineteen (19) batteries, was built and the data on nine (9) batteries is shown. These batteries were tested at +140°F and +20°F at 300 RPS except for two (2) units which were at 0 RPS.

Group II consisted of fifteen (15) batteries which are identical to Group I except they are annular cell 1-1/4" diameter. The performance of Group I can be compared directly to Group II to evaluate the "D" cell versus annular cell configuration.

Group III, six (6) batteries, is the "D" cell configuration with the binder reduced to 12-1/2%. Only three (3) batteries were fired from this group.

BUILD FOR LOT 6

Group I (Same as Lot 5 - Group 3) 19

D-Cell Configuration

1. DEB (15% Binder)
   a) Weight - 1.00 gm/pellet
   b) Thickness - .038 ± .001"
   c) Density - 1.77 to 1.87 g/cc

2. Heat 86/14 Lot 1224
   a) Weight - 1.15 g/pellet
   b) Thickness - .023 ± .001"
   c) Density - 3.30 to 3.65 g/cc
   d) With grid

3. Wrap as follows:
   a) One inner wrap of .005 glass cloth tape
   b) Three wraps of .040" fiberfrax
   c) Bring lead up with mica underlay
   d) One wrap .005 glass cloth tape
   e) Mica case liner

Group II (Same as Group I except Annular Configuration)

Annular Cell Configuration

1. DEB (15% Binder)
   a) Weight - 1.28 gm/pellet
   b) Thickness - .038 ± .001
   c) Density - 1.77 to 1.87 g/cc

2. Heat 86/14 Lot 1224
   a) Weight - 1.47 gm/pellet
   b) Thickness - .023 ± .001
   c) Density - 3.30 to 3.65 g/cc
   d) With grid

3. Wrap as follows:
   a) One inner wrap of .005 glass cloth tape
   b) Three wraps of .040 fiberfrax
   c) Bring leads up with mica underlay
   d) One wrap of .005 glass cloth tape
   e) Mica case liner

Group III (6 batteries)

"D" Cell Configuration

1. DEB (12-1/2% Binder)
   a) Weight - 1.00 gm/pellet
   b) Thickness - .038 ± .001"
   c) Density - 1.77 to 1.87 g/cc

2. Heat 86/14 Lot 1224
   a) Weight - 1.15 g/pellet
   b) Thickness - .023 ± .001
   c) Density Range - 3.30 to 3.65 g/cc
   d) With Grid

3. Wrap as follows:
   a) One inner wrap of .005 glass cloth
   b) Three wraps of .040 fiberfrax
   c) Bring leads up with mica underlay
   d) One wrap of .005 glass cloth tape
   e) Mica case liner

WOX93E LOT 6 DISCHARGE SUMMARY

S/N	23*	25	20	3*	7	11	13	8	16	18
GROUP	III	III	III	I	I	I	I	I	I	I
% B	12½	12½	12½	15%	15%	15%	15%	15%	15%	15%
DEB/HP	.87	.87	.87	.87	.87	.87	.87	.87	.87	.87
DEB WT	1.00g.	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
OHMS	20	20	20	20	20	20	20	20	20	20
T °F	140°	+20	+20	+20	+20	+20	+140	+140	+140	+140°
RPS	300	300	300	300	300	300	300	300	-0-	300
ACT 12	2.32		0.44	0.48	0.38	0.44	0.40	0.33	0.38	0.44
LIFE 12	71.0		91.0	90.	116	90	45	87	149	[illegible]
V MAX	18.2	[illegible] FAILURE [illegible] WIRES [illegible]	18.2	17.9	18.2	18.2	17.8	17.9	17.7	17.9
10 SEC	18.1		18.3	17.8	18.0	18.0	17.7	17.9	17.9	17.7
20	17.2		17.8	17.8	17.5	18.0	17.0	17.5	17.8	17.6
30	16.4		17.3	17.7	17.5	17.6	15.5	16.8	17.7	17.2
40	15.3		16.6	17.6	17.2	17.0	14.8	15.8	17.5	16.4
50	14.1		15.6	17.2	17.0	15.5	7.2	15.2	17.2	15.9
60	13.1		14.6	16.4	16.5	14.6		14.6	17.1	15.3
70	12.2		14.2	16.0	16.1	14.0		13.7	16.8	14.8
80	9.7		13.3	15.2	15.4	13.2		12.7	16.4	13.9
90	8.0		12.3	13.2	14.8	12.0		11.6	15.9	12.9
100			10.6	8.0	14.0	9.9		10.3	15.4	9.0
110			9.3		12.8			9.0	14.7	
120			8.7		11.5				14.1	
130					10.4				13.4	
140					9.3				12.7	
150									11.9	
160									10.6	
170										
180										
NOISE	.2Vat 68 sec, 72 [illegible] .2Volts at 71-79 [illegible]		1.0Volt [illegible]	1.0V Noise is [illegible]	.5Vmax [illegible] 15 [illegible] 25 sec.	200mV AT [illegible] LIFE	100mV [illegible]	[illegible]		1.0-1.5V NOISE AT 90 sec

(* NO MICA ON HEADER) — LEAD INSULATION ON TOP OF THE HEADER MELTED AND SHORTED TOGETHER. I INSTALLED MICA DISC [illegible] OF THE HEADER TO HELP PREVENT SHORTING.

WOX 93E LOT 6 DISCHARGE SUMMARY

S/N	5	14	5	11	4	12	6	10	2	14
GROUP	I	I	II	II	II	II	II	II	II	II
% B	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%
DEL/HP	.87	.87	.87	.87	.87	.87	.87	.87	.87	.87
DEB WT	1.00	1.00	1.00A	1.00A	1.00A	1.00A	1.00A	1.00A	1.00A	1.00A
OHMS	20	20	20	20	20	20	20	20	20	20
T °F	140°	20°	+20	+20	+140	+140	+140	+140	+20	+20
RPS	300	-0-	300	300	300	300	300	300	300	300
ACT 12	0.38	0.40	0.33	0.35	0.30	0.35	0.34	0.32	0.30	0.38
LIFE 12	83	127	82	83	104	79	106	106	77	85
V MAX	18.0	18.1	18.0	17.9	18.1	18.1	18.1	18.1	18.15	17.90
10 SEC	17.9	18.0	17.8	17.9	17.9	17.9	17.9	17.9	18.0	17.8
20	17.4	17.8	17.8	17.9	17.8	17.8	17.8	17.8	17.9	17.7
30	16.7	17.4	17.7	17.8	17.6	17.7	17.5	17.5	17.7	17.6
40	15.7	17.2	17.5	17.6	17.0	17.2	17.0	17.0	17.5	17.3
50	14.4	16.8	17.2	17.3	16.5	16.6	16.4	16.3	17.1	16.8
60	13.7	16.3	16.6	16.7	15.7	15.9	15.7	15.6	16.3	16.0
70	13.4	15.8	16.2	15.4	14.8	15.0	14.9	14.7	14.3	15.3
80	12.6	15.8	12.5	12.9	13.9	11.7	14.1	13.8	10.5	13.3
90	8.2	15.2	9.8	9.8	13.0	8.0	13.2	13.0	8.2	10.0
100		14.2	8.2	7.5	12.2		12.4	12.3		7.2
110		13.7			11.7		11.7	11.8		
120		12.8			11.0		11.0	11.2		
130		11.7			10.4		10.2	10.6		
140		10.7			9.8		9.4	10.0		
150					9.2		8.6	9.3		
160					8.7			8.7		
170										
180										
NOISE	.8V NOISE AT 54 SEC CONTINUOUS [illegible]	.6V AT 55 SEC - [illegible] LIFE	NONE!	NONE!	NONE!	Noise at 75 sec [illegible]	NONE!	NONE!	NONE!	NONE!

LOT 07

Group I - (3 batteries) (S/N K4-12-1, 2, and 3)

Configuration 1" dia.

1) DEB (15% Binder)

   a) Weight 0.82 gm/pellet (punch down from 1¼" dia. cell weighing 1.28 gm from Lot 06)

   b) Thickness .038 ± .001"

   c) Density 1.77 to 1.87 gm/cc.

2) Heat (86/14 Lot 1224) 1" dia.

   a) Weight .85 gm/pellet.

   b) Thickness .021 ± .001".

   c) Density 3.30 to 3.65 gm/cc.

   d) With grid.

3) Wrap

   a) One inner wrap of .005 glass cloth tape.

   b) Special MIN-K insulator furnished.

   c) Mica case liner.

Group II - (2 batteries) (S/N K4-26-1, 2)

Configuration 1" dia.

1) DEB (15% Binder)

   a) Weight 0.82 gm/pellet.

   b) Thickness .038 ± .001".

   c) Density 1.77 to 1.87 gm/cc.

2) Heat (86/14 Lot 1224) 1" dia.

   a) Weight .85 gm/pellet.

   b) Thickness .038 ± .001"

c) Density 1.77 to 1.87 gm/cc.

d) With grid.

3) Wrap

a) One inner wrap of .005 glass tape.

b) .010" asbestos wrap 1-3/16 x 3/78.

c) Heat paper wrap 393 cal/gm 3.25 x 1.25 - 1.68 gm.

d) MIN-K insulator (I.D. enlarged .045").

c) .005 mica case liner.

Group III - (13 batteries) (S/N L4-13-1 thru 9 and S/N L4-7-1 thru 4)

Configuration 1¼" dia.

1) DEB (15% Binder)

a) Weight 1.28 gm/pellet.

b) Thickness .038 ± .001".

c) Density 1.77 to 1.877 gm/cc.

2) Heat (86/14 Lot 1224)

a) Weight 1.47 gm/pellet.

b) Thickness .022 ± .001".

c) Density 3.30 to 3.65 gm/cc.

d) With grid.

3) Wrap.

a) One inner wrap of .005 glass cloth tape.

b) Bring leads up with mica underlay.

c) Fiberfrax rigid tube I.D. 1.31, O.D. 1.50, HGT. 1.32".

d) Mica case liner.

Group IV - (6 batteries) (S/N L4-16-1 thru 6)

Configuration 1" dia. cell

1) DEB (15% Binder)

a) Weight .82 gm/pellet

b) Thickness .038 ± .001".

c) Density 1.77 to 1.87 gm/cc.

2) Heat (86/14 Lot 1224)

a) Weight .88 gm/pellet.

b) Thickness .021 ± .001"

c) Density 3.30 to 3.65 gm/pellet.

d) With grid.

3) Wrap

a) .005 glass cloth tape - inner wrap.

b) .005 mica

c) .020 asbestos 1.19 x 1.875.

d) .010 asbestos 1.19 x 1.81.

e) Two heat wrap 393 cal/gm 3.25 x 1.25 - 1.68 gm.

f) .010 asbestos wrap 1.19 x 1.44.

g) Fiberfrax rigid insulator I.D. 1.31", O.D. 1.50", Hgt. 1.32"

h) Mica case liner.

Group V - (6 batteries) (S/N L4-16-7 thru 12)

Configuration 1" dia. cell.

1) DEB (15% Binder)

a) Weight .82 gm/pellet.

b) Thickness .038 ± .001".

c) Density 1.77 to 1.87 gm/cc.

2) Heat (86/14 Lot 1224)

a) Weight .94 gm/pellet

b) Thickness .023 ± .001"

c) Density 3.30 to 3.65 gm/cc.

d) With grid.

3) Wrap

a) .005 glass cloth tape - inner wrap.

b) .005 mica.

c) .020 asbestos 1.19 x 1.875.

d) .010 asbestos 1.19 x 1.81.

e) Two heat wrap 393 cal/gm 3.25 x 1.25 - 1.68 gm.

f) .010 asbestos wrap 1.19 x 1.44.

g) Fiberfrax rigid insulator I.D. 1.31", O.D. 1.50", Hgt. 1.32".

h) Mica case liner.

Group VI - (6 batteries) (S/N L4-16-13 thru 18)

Configuration 1" dia. cell.

1) DEB (15% Binder)

a) Weight .82 gm/pellet.

b) Thickness .038 $\pm$ .001".

c) Density 1.77 to 1.87 gm/cc.

2) Heat (86/14 Lot 1224)

a) Weight .94 gm/pellet.

b) Thickness .023 $\pm$ .001".

c) Density 3.30 to 3.65 gm/cc.

d) With grid.

3) Wrap

a) .005 glass cloth tape - inner wrap.

b) .005 mica.

c) .020 asbestos 1.19 x 1.875.

d) .010 asbestos 1.19 x 1.81.

e) One heat wrap 393 cal/gm 3.25 x 1.25 = 1.68 gm.

f) .010 asbestos wrap 1.19 x 1.44.

g) Fiberfrax rigid insulator I.D. 1.31", O.D. 1.50", Hgt. 1.32".

h) Mica case liner.

Group VII - (5 batteries) (L4-16-19 thru 23)

Configuration 1" dia. cell.

1) DEB (15% Binder).

a) Weight .90 gm/pellet.

b) Thickness .041 $\pm$ .001".

c) Density 1.77 to 1.87 gm/cc.

2) Heat (86/14 Lot 1224)

a) Weight .85 gm/pellet.

b) Thickness .021" $\pm$ .001".

c) Density 3.30 to 3.65 gm/cc.

d) No grid.

3) Wrap

a) .005 glass cloth tape - inner wrap.

b) .005 mica.

c) .020 asbestos 1.19 x 1.875.

d) .010 asbestos 1.19 x 1.81.

e) Two heat wrap 393 cal/gm 3.25 x 1.25 = 1.68 gm.

f) .010 asbestos wrap 1.19 x 1.44.

g) Fiberfrax rigid insulator I.D. 1.31", O.D. 1.50", Hgt. 1.32".

h) Mica case liner.

WOX 93E LOT 7 DISCHARGE SUMMARY

S/N	K11-12 S/N 1	K11-12 S/N 3	K11-12 S/N 2		K4-26 S/N 1	K4-26 S/N 2	L4-7-1	L4-7-2	L4-7-3	L4-7-4
GROUP	I	I	I		II	II	III	III	III	
% B	15%	15	15		15	15	15	15	15	
DEB/HP	1.0	1.0	1.0		1.0	1.0	.87	.87	.87	
DEB WT	.82	.82	.82		.82	.82	1.28	1.28	1.28	
OHMS	20	20	20		20	20	20	20	20	
T °F	+140°F	+200	+200		140°F	+200°F	+175	+175	+140	
RPS	300	300	300		300	300	0	0	0	
CELL SIZE	1"	1"	1"		1" [illegible]	→	1¼	1¼	1¼	
ACT 12	.45	.60	.35		.35	.40	.35	.35	.30	
LIFE 12	70.5	49.0	35		54	92	97	96	95	
V MAX	16.7	15.6	16.0		17.8	17.2	17.9	18.0	17.8	
10 SEC	16.0	14.5	15.8		17.3	17.2	17.9	17.9	17.8	
20	15.9	14.7	15.7		17.2	17.1	17.8	17.8	17.7	
30	15.8	13.9	14.5		16.6	16.8	17.8	17.7	17.7	
40	15.8	13.0	8.2		15.4	16.2	17.6	17.6	17.6	
50	15.4	11.9			13.3	15.7	17.3	17.3	17.3	
60	14.3	10.5				14.8	16.8	16.7	16.7	
70	13.1	9.8				14.0	16.1	15.8	16.0	
80		7.7				13.3	14.9	14.7	14.7	
90		9.8				12.1	13.5	13.2	13.1	
100		10.6				11.2	11.2	11.3	11.0	
110		9.0				10.5	8.7	8.9	8.9	
120						9.8		7.1		
130						9.0				
140						8.3				
150						7.8				
160										
170										
180										
NOISE	CELL SHORTING AT 70 SEC.	CELL SHORTING AT 110 SEC.	CELL NOISE AT 38 SEC		Noise at 53 sec. voltage went at 2 V. before [illegible]	NONE	NONE	NONE	NONE	NOT TESTED - FIXTURE FAILURE

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WOX 93E LOT 7 DISCHARGE SUMMARY

S/N	X 1	X 2	X 3	4	5	** 6	** 7	** 8	** 9
GROUP	III	III	III	III	III	III	III	III	
% B	15	15	15	15	15	15	15	15	15
DEB/HP	.87	.87	.87	.87	.87	.87	.87	.87	.87
DEB WT	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28
OHMS	20	20	20	20	20	20	20	20	20
T °F	+140	+120	+120	[illegible]	+140°	+140°F	+120°F	75°F	+140°F
RPS	-0-	-0-	-0-	300	300	300	300	300	300
CELL DIA	1 1/4"	1 1/4"	1 1/4"	1 1/4"	1 1/4"	1 1/4"	1 1/4"	1 1/4"	1 1/4"
ACT 12	.35	.29	.30	.27		.33	.34	.32	.25
LIFE 12	112	106	116	20		116	97	121	120
V MAX	17.9	18.00	17.97	12.7		17.8	18.06	17.94	18.05
10 SEC	17.8	18.0	18.0	15.6		17.7	18.0	17.7	17.8
20	17.9	18.0	17.9	12.0		17.8	18.0	17.8	17.9
30	17.9	18.0	17.9	12.5		17.8	17.9	17.9	17.9
40	17.7	17.9	17.8	13.1		17.6	17.7	17.6	17.7
50	17.5	17.6	17.6	12.8		17.3	17.5	17.5	17.5
60	17.2	17.4	17.4	11.6		16.7	17.2	17.2	17.0
70	16.6	16.6	16.8	12.3		16.2	16.4	16.1	16.4
80	16.2	15.9	16.3	11.9		15.4	15.4	16.5	15.7
90	15.3	14.7	15.3	11.7		14.4	13.7	15.4	14.9
100	14.1	13.3	14.7	11.4		13.4	11.0	14.7	14.0
110	12.4	11.3	13.2	11.1		12.4	8.4	13.8	12.2
120	10.2	9.2	11.3	9.1		11.6		12.7	12.3
130	7.7					10.9		12.1	11.5
140						10.2		10.1	11.0
150						9.1		10.7	
160								10.5	
170								[illegible]	
180								8.8	
NOISE	NONE	NONE	NONE	2.0 VOLTS AT 5.0 SEC. [illegible] AT 13.0 SEC.		NONE	NONE	NONE	NONE

X = NEW TERMINAL [illegible] CASE.

** = NEW wire in fixture & tailgate.

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WOX 93E LOT 7 DISCHARGE SUMMARY

S/N	1	2 **	3	4 **	5 **	6 **	7	8	9	10
GROUP	IV	IV	IV	IV	IV	IV	V	V	V	V
% B	15	15	15	15	15	15	[illegible]	15	15	15
DEB/HP	.93	.93	.93	.93	.93	.93	[illegible]	.87	.87	.87
DEB WT	.82	.82	.82	.82	.82	.82	[illegible]	.82	.82	.82
OHMS	20Ω	20Ω	20Ω	2Ω	20Ω	20Ω	[illegible]	20Ω	20Ω	20Ω
T °F	+20°	+140	+75	+140	+20	+140	[illegible]	+140	75	75
RPS	-0-	-0-	300	0	300	300	0	0	300	300
CELL DIA	1"	1"	1"	1"	1"	1"	1"	1"	1"	1"
ACT 12	.32	.39	.40	.27	.38	.28	[illegible]	[illegible]		.26
LIFE 12	106	66	28	77	16	52	[illegible]	13		67
V MAX	17.6	17.5	17.2	17.6	16.3	17.4	15.7	17.40		17.3
10 SEC	17.3	16.6	16.7	16.6	15.2	16.6	15.4	16.4		14.7
20	16.8	16.2	16.4	16.1		16.7	14.6			14.9
30	16.5	15.7	9.4	15.7		16.1	13.6			14.6
40	15.9	14.8		15.2		14.0	13.2			14.5
50	15.4	13.6		14.5		13.6	12.7			13.6
60	14.8	12.5		13.4			[illegible]			12.[illegible]
70	14.4	11.6		12.5			11.2			11.7
80	13.8	10.5		11.7			10.2			
90	13.2	10.2					9.7			
100	12.4	10.0					9.2			
110	11.7	7.8					9.0			
120	11.0									
130	10.4									
140	9.6									
150										
160										
170										
180										
NOISE	NONE	.5V at 47 sec. Noise [illegible] [illegible]	SEVERE AT 25 sec	.5V at 44 sec	SEVERE at 16 sec	1.0V at 33 sec. 1.0V all [illegible] [illegible] at [illegible] [illegible]	NONE			Noise [illegible] [illegible]

S/N 8 (written sideways): [illegible] dropped to 0 at 12.0 sec. — Reel pulled away from terminal on [illegible] entry. Diff. left.

S/N 9 (written sideways): No voltage see attached sheet

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WOX 93E LOT 7 DISCHARGE SUMMARY

S/N	** 11	** 12	13	14	15	14	** 17	** 18
GROUP	V	V	VI	VI	VI	VI	VI	VI
%B	15	15	15%	15%	15	15	15	15
DEB/HP	.87	.87	.87	.87	.87	.87	.87	.87
DEB WT	.82	.82	.82	.82	.82	.82	.82	.82
OHMS	20Ω	20Ω	20Ω	20	20	20	20	20
T °F	140	20	20°F	[illegible]	75°	75°	[illegible]	[illegible]
RPS	0	300	-0-	-0-	300	300	[illegible]	[illegible]
ACT12	.28		.33	.29		1.84	.28	1.3
LIFE12	32		98	83		~~[illegible]~~ 26	38	50
						~~[illegible]~~		
V MAX	17.2		17.7	17.52		14.4	17.0	17.0
10 SEC	13.9		17.2	16.7		13.4	17.0	13.6
20	14.4		17.0	17.1		13.0	17.0	14.0
30	12.7		16.8	[illegible]		11.4	16.0	12.5
40	9.6		16.4	15.6			11.8	12.7
50			15.8	15.2				12.0
60			15.2	14.3				
70			14.4	13.2				
80			13.7	12.2				
90			12.8	11.5				
100		Noticed when T [illegible] [illegible]	11.8	10.8	No voltage output. See report. Bad connection on terminal [illegible]	Cell repaired [illegible] Post mortem report, 12/3/74		
110			10.3	10.5				
120			9.5	10.3				
130			9	10.0				
140				9.7				
150								
160								
170								
180								
NOISE	Somewhat 4.0 sec [illegible]		None	None			Some at 36 sec	Somewhat at [illegible] sec. [illegible] 18 [illegible]

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WOX 93E LOT 7 DISCHARGE SUMMARY

S/N	** 19	** 20	** 21	** 22	** 23					
GROUP	VII	VII	VII	VII	VII					
% B	15%	15%	15%	15%	15%					
DEB/HP	1.05	1.05	1.05	1.05	1.05					
DEB WT	.90	.90	.90	.90	.90					
OHMS	20	20	20	20	20					
T °F	75	+20°F	+140	+20°F	+170°F					
RPS	300	300	300	0	0					
ACT 12	.32	.29	.30	.34	.32					
LIFE 12	84	95	66	?3	113					
V MAX	17.7	17.7	17.2	17.7	17.7					
10 SEC	17.7	17.7	16.5	17.6	17.6					
20	17.6	17.5	16.3	17.4	17.4					
30	17.3	17.2	15.7	17.1	17.3					
40	17.1	16.7	14.7	16.6	17.0					
50	16.5	16.1	13.6	15.7	16.5					
60	15.7	14.8	12.7	14.3	15.7					
70	14.5	13.6	11.6	13.2	15.2					
80	12.5	12.5		12.3	14.4					
90	-	11.4		11.4	13.6					
100					12.8					
110					12.3					
120					11.5					
130										
140										
150										
160										
170										
180										
NOISE	(NONE)	(NONE)	3.0V at 7 SEC.	NONE	(NONE)					

BATTERY KEPT IN POCKET AT 72°F.

LOT 08

Group I - (27 batteries)

Configuration 1" dia. cell.

1) DEB (15% Binder).

   a) Weight .90 gm/pellet.

   b) Thickness .041 ± .001".

   c) Density 1.77 to 1.87 gm/cc.

2) Heat (86/14 Lot 1224)

   a) Weight .85 gm/pellet.

   b) Thickness .021" ± .001".

   c) Density 3.30 to 3.65 gm/cc.

   d) No grid.

3) Wrap

   a) .005 glass cloth tape - inner wrap.

   b) .005 mica.

   c) .020 asbestos 1.19 x 1.875.

   d) .010 asbestos 1.19 x 1.81.

   e) Two heat wrap 393 cal/gm 3.25 x 1.25 = 1.68 gm.

   f) .010 asbestos wrap 1.19 x 1.44.

   g) Fiberfrax rigid insulator I.D. 1.31", O.D. 1.50", Hgt. 1.32".

   h) Mica case liner.

Jan 197[illegible]

WOX 93E LOT 8 DISCHARGE SUMMARY

S/N	S/N A5-31-2	A5-31-3	A5-31-4	A5-31-7	A5-21	A5-23				
GROUP										
% B										
DEB/HP										
DEB WT										
OHMS										
T °F	+75°F	+75°F	+75°F	+75°F	+75°F	+75°F				
RPS	300	300	300	300	-0-	-0-				
ACT 12	.310	.346	.462	.387	.37	.35				
LIFE 12	127	73	114.5	96	102	106				
V MAX	17.9	17.0	17.95	17.5	17.2	17.5				
10 SEC	17.8	16.6	17.7	17.3	16.6	16.8				
20	17.9	16.0	17.8	17.5	16.3	16.6				
30	17.75	16.0	17.7	17.45	15.8	16.3				
40	17.5	15.7	17.45	17.05	14.6	15.8				
50	17.2	14.95	17.0	16.5	14.5	15.4				
60	16.7	13.8	16.45	15.8	14.1	14.7				
70	16.1	12.5	15.9	15.0	13.6	14.3				
80	15.5	9.6	14.95	14.3	13.1	13.6				
90	14.8		14.0	13.45	12.7	13.1				
100	14.1		13.2	11.6	12.1	12.4				
110	13.5		12.45	8.5	11.6	11.6				
120	12.7		11.5							
130	11.7		10.7							
140	10.8		9.7							
150	9.8		8.0							
160	8.9									
170										
180										
NOISE	.8 V noise @ 20 sec	.2 V noise starting @ 73 sec	No noise	94 sec [illegible]	None	None				

ATTN BEN LARRICK

Jan 197[illegible]

WOX 93E LOT 8 DISCHARGE SUMMARY

S/N	A5-31-9	A5-31-10	A5-31-11	A5-31-15	A5-8	A5-1
GROUP						
% B						
DEP/HP						
DEP WT						
OHMS						
T °F	+140°F	+140°F	+140°F	+140°F	+140°F	+140°F
RPS	300	300	300	300	-0-	-0-
ACT 12	.403	.451	.425	.177	.37	.37
LIFE 12					72	46
V MAX	16.75	16.2	16.45	15.3	16.6	16.3
10 SEC	16.45	15.4	15.8	14.1	16.2	149
20	16.45	14.7	15.6	13.2	15.8	13.9
30	16.45	13.6	15.15	12.7	15.4	13.4
40	15.7	10.5	9.6	9.8	15.0	12.8
50	14.5	noise out		noise out	14.3	11.5
60	10.7				13.3	
70	7.0				12.3	
80					11.4	
90						
100						
110						
120						
130						
140						
150						
160						
170						
180						
NOISE					NONE	NONE

June 1973

WOX 93E LOT 8 DISCHARGE SUMMARY

S/N	A5-31-12	A5-31-13	A5-31-14	A5-31-16	A5-6	A5-5				
GROUP										
% B										
DEB/HR										
DEB WT										
OHMS										
T °F	+20°F	+20°F	+20°F	+20°F	+20°F	+20°F				
RPS	300	300	300	300	-0-	-0-				
ACT 12	.4838	.457	.451	.418	.37	.38				
LIFE 12	140	60	81	95	66	147				
V MAX	17.8	16.35	16.20	17.4	16.7	17.6				
10 SEC	17.7	15.5	16.1	17.5	15.8	17.5				
20	17.7	15.2	15.65	17.2	15.2	17.6				
30	16.6	15.0	15.1	16.95	14.4	17.5				
40	17.1	14.0	14.7	16.2	13.6	17.4				
50	17.05	13.1	14.25	16.1	12.9	17.3				
60	17.0	12.0	13.55	15.7	12.4	16.8				
70	16.55	8.6	13.5	14.9	11.8	16.5				
80	16.05		12.15	13.8		16.2				
90	15.5		10.7	12.7		15.6				
100	14.8		9.9	11.5		14.8				
110	14.0			10.2		14.3				
120	13.2			8.7		13.6				
130	12.5					12.9				
140	12.0					12.4				
150	11.3					11.8				
160	10.6									
170	9.7									
180	9.0									
NOISE		-								
		-								

LOT 09

Group I - (20 batteries)

Configuration 1" dia. cell.

1) DEB (15% Binder).

   a) Weight .90 gm/pellet.

   b) Thickness .041 ± .001".

   c) Density 1.77 to 1.87 gm/cc.

2) Heat (86/14 Lot 1224).

   a) Weight .85 gm/pellet.

   b) Thickness .021" ± .001".

   c) Density 3.30 to 3.65 gm/cc.

   d) No grid.

3) Wrap

   a) .005 glass cloth tape - inner wrap.

   b) .005 mica.

   c) .020 asbestos 1.19 x 1.875.

   d) .010 asbestos 1.19 x 1.81.

   e) Two heat wrap 393 cal/gm 3.25 x 1.25 = 1.68 gm.

   f) .010 asbestos wrap 1.19 x 1.44.

   g) Fiberfrax rigid insulator I.D. 1.31", O.D. 1.50", Hgt. 1.32".

   h) Mica case liner.